DOCKET NO; 281994US0PCT





IN RE APPLICATION OF

KOICHI SAKAMOTO, ET AL.

: EXAMINER: SHEVIN, MARK L.

SERIAL NO: 10/564,061

FILED: JANUARY 10, 2006

: GROUP ART UNIT: 1793

FOR: METHOD FOR PRODUCING HIGH CLEANNESS STEEL EXCELLENT IN FATIGUE STRENGTH OR COLD WORKABILITY

DECLARATION UNDER 37 CFR 1.132

COMMISSIONER FOR PATENTS ALEXANDRIA, VIRGINIA 22313

SIR:

I, Koichi SAKAMOTO, a citizen of Japan,

hereby declare and state that;

- 1. I am a co-inventor of the above-identified application.
- 2. The attached Tables 1, 2, 3 and 4 are the Tables 1, 2, 3 and 4 mentioned in the specification at [0065], [0066], [0073] and [0074], respectively.
- 3. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issuing thereon.
- 4. Further declarant saith not.

Date: September 22, 2008 Koichi Sakamoto

Koichi SAKAMOTO, Dr.Eng.

Declarant's Name (typed)

Attached: Tables 1,2,3 and 4

TABLE 1

Adding time Adding time Adding time Adding time Adding time Dostor Adding time Dostor Adding time Adding time Dostor Adding time Adding t	8	8	8	၂ဒ	Composition	ition					Li adding method					Number of oxide		
After the steed melting process Lade Wire 1,43×10° 0.3 (Number per 50g of Freequeinvol Precision) (Freequeinvol Precision) After the steed melting process Lade Wire 1,43×10° 0.3 0.0 5 5 After the steed melting process Lade Wire 1,50×10° 0.1 0.16 6 6 After the steed melting process Lade Wire 1,50×10° 0.1 0.0 2 0 After the steed melting process Lade Wire 1,50×10° 0.1 0.0 0	C Si Mn A Ca Mg	Mn A Ca Mg	A Ca Mg	Ca Mg	Mg	-	0	1	<u> </u>	i.containing materia	Adding inc	Adding	Adding	Li content of steel /Si content of steel	Stag stag	indusion partides of 20 µm or above	Drawability	size of the largest indusion partide
After the steed meding process Lade Wive 1,43+10 ⁵ 0.3 0.20 5 After the steed meding process Lade Wive 5,25+10 ⁵ 0.2 0.18 6 After the steed meding process Lade Wive 1,20+10 ⁴ 0.1 0.20 0.10 2 After the steed meding process Lade Mye 1,78+10 ⁴ 0.2 0.10 2 0.10 After the steed meding process Lade Mye 1,78+10 ⁴ 0.1 0.23 5 0.1 After the steed meding process Lade Mye 3,38+10 ⁴ 0.3 0.18 1 1 After the steed meding process Lade Wive 8,59+10 ⁴ 0.5 0.13 6 1 After the steed meding process Lade Wive 8,50+10 ⁴ 0.5 0.13 6 1 Initial stage of the steed meding process Lade Wive 8,50+10 ⁴ 0.5 1.0 3 1 Initial stage of the steed meding process Lade <th>(% by mass) (ppm)</th> <th></th> <th></th> <th>(wdd)</th> <th>(mdd)</th> <th>(mdd)</th> <th>_</th> <th></th> <th></th> <th></th> <th>o de la composición dela composición de la composición de la composición dela composición dela composición dela composición de la composición dela composición del composición dela compo</th> <th>position</th> <th>method</th> <th>(% by mass)</th> <th>(% by mass)</th> <th>(Number per 50g of steel)</th> <th>(Frequency of breakage)</th> <th>(mrl)</th>	(% by mass) (ppm)			(wdd)	(mdd)	(mdd)	_				o de la composición dela composición de la composición de la composición dela composición dela composición dela composición de la composición dela composición del composición dela compo	position	method	(% by mass)	(% by mass)	(Number per 50g of steel)	(Frequency of breakage)	(mrl)
After the steed meding process Lade Wive 1,20×10 ⁴ 0.1 0.11 6 After the steed meding process Lade Wive 1,70×10 ⁴ 0.1 0.09 0 After the steed meding process Lade Injection 2,19×10 ⁴ 0.1 0.09 0 After the steed meding process Lade Injection 3,35×10 ⁴ 0.1 0.09 0 After the steed meding process Lade Injection 3,35×10 ⁴ 0.3 0.16 3 After the steed meding process Lade Injection 3,35×10 ⁴ 0.5 0.18 1 After the steed meding process Lade Wive 6,05×10 ⁴ 0.5 0.18 6 After the steed meding process Lade Wive 6,29×10 ⁴ 0.5 0.19 6 Initial stage of the steed meding process Lade Wive 5,09×10 ⁵ 1.1 1.2 6 Initial stage of the steed meding process Lade More 5,09×10 ⁵ 1.5 1.10 6	0.72 0.21 0.52 0.003 10.1 0.7 10 0.030	0.52 0.003 10.1 0.7 10	0.003 10.1 0.7 10	10.1 0.7 10	0.7 10	0		0.03		EO241	After the steel melting process	Lade	Wire	1.43×10 ⁵	0.3	0.20	5	20
After the steel mething process Lade Wire 1.20x10 ⁴ 0.1 0.21 6 After the steel mething process Lade Nine 1.78x10 ⁴ 0.1 0.09 0 After the steel mething process Lade Injection 2.19x10 ⁴ - 0.09 0 After the steel mething process Lade Injection 3.36x10 ⁴ - 0.18 1 After the steel mething process Lade Injection 3.36x10 ⁴ 0.3 0.16 1 After the steel mething process Lade Injection 3.36x10 ⁴ 0.5 0.13 6 After the steel mething process Lade Nive 6.23x10 ⁴ 0.5 0.13 6 After the steel mething process Lade Wire 6.29x10 ² 0.6 0.19 5 Initial stage of the steel mething process Lade Nive 6.29x10 ² 0.6 0.19 5 Initial stage of the steel mething process Lade Nive 6.29x10 ² 2.6 1.0 5 <td>0.70 0.20 0.52 0.004 13.1 1.0 13 0.105</td> <td>0.52 0.004 13.1 1.0 13</td> <td>0.004 13.1 1.0 13</td> <td>13.1 1.0 13</td> <td>1.0 13</td> <td>13</td> <td></td> <td>0.105</td> <td>L</td> <td>L½CO₃+Ca</td> <td>After the steel melting process</td> <td>Lade</td> <td>Wire</td> <td>5.25×10⁻⁵</td> <td>0.2</td> <td>0.18</td> <td>9</td> <td>18</td>	0.70 0.20 0.52 0.004 13.1 1.0 13 0.105	0.52 0.004 13.1 1.0 13	0.004 13.1 1.0 13	13.1 1.0 13	1.0 13	13		0.105	L	L½CO ₃ +Ca	After the steel melting process	Lade	Wire	5.25×10 ⁻⁵	0.2	0.18	9	18
After the steed meding process Lade Wire 1,78x10 ⁴ 0.1 0.09 0 After the steed meding process Lade Injection 2,19x10 ⁴ 0.1 0.09 0 After the steed meding process TD Injection 3,36x10 ⁴ - 0.18 1 After the steed meding process Lade Injection 3,36x10 ⁴ 0.5 0.13 5 After the steed meding process Lade Wire 6,05x10 ⁴ 0.5 0.13 5 After the steed meding process Lade Wire 8,36x10 ⁴ 0.5 0.13 6 After the steed meding process Lade Wire 8,36x10 ⁴ 0.5 0.13 6 After the steed meding process Lade Wire 8,26x10 ⁴ 0.5 0.13 6 Initial stage of the steed meding process Lade Wire 8,06x10 ⁴ 0.6 0.19 5 Initial stage of the steed meding process Lade Mort 9,16x10 ⁶ 2.5 1.10 54	0.73 0.20 0.49 0.003 13.0 1.2 15 0.240	0.49 0.003 13.0 1.2 15	0.003 13.0 1.2 15	13.0 1.2 15	1.2 15	15		0.240		L _P CO ₃	After the steel melting process	Lade	Wire	1.20×10 ⁻⁴	0.1	0.21	9	18
After the steed meding process Lade Injection 2.19×10 ⁴ 0.1 0.09 0 After the steed meding process TD Injection 3.36×10 ⁴ - 0.18 1 - After the steed meding process Lade Injection 3.96×10 ⁴ 0.5 0.16 3 - After the steed meding process Lade Wire 6.06×10 ⁴ 0.5 0.13 6 - After the steed meding process Lade Wire 8.95×10 ⁴ 0.5 0.19 6 - After the steed meding process Lade Wire 8.95×10 ³ 0.5 0.19 6 - Initial stage of the steed meding process Lade Wire 5.08×10 ³ 1.7 1.02 37 - Initial stage of the steed meding process Lade Wire 9.18×10 ³ 2.6 1.10 5.1 - Initial stage of the steed meding process Lade Nive 9.08×10 ⁵ 1.5 1.10 5.4 - Initial stage	0.72 0.18 0.49 0.003 12.5 0.8 14 0.320	0.49 0.003 12.5 0.8 14	0.003 12.5 0.8 14	12.5 0.8 14	0.8	14	ļ	0.320	ı	L½CO3+Ca,Na, K	After the steel melting process	Lade	Wire	1.78×10 ⁴	0.2	0.10	2	17
After the steel melting process TD injection 336×10 ⁴ - 0.23 5 After the steel melting process Lade Injection 336×10 ⁴ - 0.16 3 After the steel melting process Lade Nére 6.05×10 ⁴ 0.5 0.13 5 After the steel melting process Lade Wére 6.05×10 ⁴ 0.5 0.13 6 After the steel melting process Lade Wére 6.29×10 ³ 2.6 1.02 37 Initial stage of the steel melting process Lade Wére 5.09×10 ³ 2.6 1.10 60 Initial stage of the steel melting process Lade Input 9.00×10 ⁶ 5.2 1.10 51 Initial stage of the steel melting process Lade Input 9.00×10 ⁶ 5.2 1.10 54 Initial stage of the steel melting process Lade Input 7.20×10 ⁶ 1.5 1.10 54 Initial stage of the steel melting process Lade Input 7.20×10 ⁶ 1.7 <	0.83 0.21 0.52 0.004 14.5 0.8 16 0.460	0.52 0.004 14.5 0.8 16	0.004 14.5 0.8 16	14.5 0.8 16	5 0.8 16	16		0.460		Li ₂ CO ₃	After the steel melting process	Lade	Injection	2.19×10 ⁻⁴	0.1	0.09	0	15
After the steel melting process MD Wire 3.38×10 ⁴ · 0.18 1 · After the steel melting process Lade Injection 3.96×10 ⁴ 0.5 0.13 5 1 After the steel melting process Lade Wire 8.33×10 ⁴ 0.5 0.25 8 5 After the steel melting process Lade Wire 8.95×10 ⁴ 0.6 0.19 6 8 Initial stage of the steel melting process Lade Wire 9.18×10 ³ 4.1 1.20 87 1.1 Initial stage of the steel melting process Lade Aloy input 0.004 1.0 2.50 87 1.1 5.1 1.1 5.4 1.1 1.2 5.1 1.1 5.2 1.1 5.2 1.1 5.2 1.1 5.2 1.1 5.2 1.1 5.2 1.1 1.2 5.2 1.1 1.2 5.2 1.1 1.2 1.2 1.2 1.2 1.2 1.2 1.2 1.2	0.83 0.20 0.50 0.003 14.1 2.5 15 0.665	0.50 0.003 14.1 2.5 15	0.003 14.1 2.5 15	14.1 2.5 15	2.5 15	15	<u> </u>	0.665		Li ₂ CO ₃ +Ca, Mg	After the steel melting process	TD	Injection	3.35×10 ⁻⁴	•	0.23	5	16
After the steed metting process Lade Injection 3.96×10 ⁴ 0.3 0.16 3 After the steed metting process Lade Wire 8.05×10 ⁴ 0.5 0.13 5 After the steed metting process Lade Wire 8.95×10 ⁴ 0.6 0.19 6 Initial stage of the steel metting process Lade Wire 6.29×10 ³ 2.6 1.02 37 Initial stage of the steel metting process Lade Wire 9.18×10 ³ 4.1 1.20 60 Initial stage of the steel metting process Lade Mive 9.18×10 ³ 4.1 1.20 60 Initial stage of the steel metting process Lade Moy input 0.004 10.0 2.50 87 60 Initial stage of the steel metting process Lade Input 7.20×10 ⁶ 1.5 1.10 54 60 Initial stage of the steel metting process Lade Input 7.20×10 ⁶ 1.5 1.10 56 60 Initial stage of the steel metting process Lade<	0.82 0.22 0.50 0.003 15.1 0.9 15 0.520	0.50 0.003 15.1 0.9 15	0.003 15.1 0.9 15	15.1 0.9 15	0.9	15	<u> </u>	0.520		Li₂CO₃+Ca	After the steel melting process	MD	Wire	3.36×10 ⁻⁴	•	0.18	1	. 16
After the steel melting process TD Wire 6.05×10 ⁴ 0.5 0.13 5 After the steel melting process Lade Wire 8.33×10 ⁴ 0.6 0.19 6 After the steel melting process Lade Wire 6.29×10 ³ 1,7 1,02 48 Initial stage of the steel melting process Lade Wire 5.09×10 ³ 2.6 1,02 37 Initial stage of the steel melting process Lade Input 9.00×10 ⁶ 5.2 1,10 51 Initial stage of the steel melting process Lade Alloy input 6.80×10 ⁶ 1,5 1,10 54 Initial stage of the steel melting process Lade Input 7.20×10 ⁶ 1,0 1,0 56 5 Initial stage of the steel melting process Lade Input 7.30×10 ⁶ 1,0 1,0 56 5 Initial stage of the steel melting process Lade Input 7.30×10 ⁶ 1,0 1,1 49 5 Initial stage of the steel melting process Lade	0.82 0.22 0.51 0.003 12.1 1.1 14 0.870	0.51 0.003 12.1 1.1 14	0.003 12.1 1.1 14	12.1 1.1 14	1.1	14		0.870		Li-70% Si afloy	After the steel metting process	Lade	Injection	3.95×10 ⁻⁴	0.3	0.16	9	18
After the steel meting process Lade Wire 8.95×10 ⁴ 0.5 0.19 6 Initial stage of the steel meting process Lade Wire 6.29×10 ³ 1.7 1.02 48 Initial stage of the steel meting process Lade Wire 5.09×10 ³ 2.6 1.02 37 Initial stage of the steel meting process Lade Wire 9.18×10 ³ 4.1 1.20 60 Initial stage of the steel meting process Lade Input 9.00×10 ⁶ 1.5 1.10 51 Initial stage of the steel meting process Lade Input 7.20×10 ⁶ 1.5 1.10 54 Initial stage of the steel meting process Lade Input 7.20×10 ⁶ 1.2 1.29 54 Initial stage of the steel meting process Lade Input 7.30×10 ⁶ 0.0 1.2 56 54 Initial stage of the steel meting process Lade Input 7.30×10 ⁶ 0.0 1.2 1.14 49 54 Initial stage of the steel meting process	0.81 0.20 0.50 0.004 15.8 2.3 15 1.210	0.50 0.004 15.8 2.3 15	0.004 15.8 2.3 15	15.8 2.3 15	23 15	15		1.210		Li-75% Si alloy	After the steel melting process	TD	Wire	6.05×10 ⁴	0.5	0.13	5	15
% Si alloy After the steed melting process Lade Wire 8.95×10 ⁴ 0.6 0.19 6 % Si alloy Initial stage of the steed melting process Lade Wire 6.29×10 ⁻³ 2.6 1.02 48 48 % Si alloy Initial stage of the steed melting process Lade Wire 9.18×10 ⁻³ 2.6 1.02 37 51 % Si alloy Initial stage of the steed melting process Lade Imput 9.00×10 ⁻⁶ 5.2 1.10 51 52 % Si alloy Initial stage of the steel melting process Lade Alloy input 0.004 1.0 2.50 87 52 <t< td=""><td>0.83 0.21 0.52 0.003 14.1 2.7 14 1.750 Li-7</td><td>0.52 0.003 14.1 2.7 14 1.750</td><td>0.003 14.1 2.7 14 1.750</td><td>14.1 2.7 14 1.750</td><td>2.7 14 1.750</td><td>14 1.750</td><td>1.750</td><td></td><td>1.7</td><td>Li-70% Si alloy + Ca, Mg</td><td>After the steel melting process</td><td>Lade</td><td>Wire</td><td>8.33×10⁴</td><td>0.5</td><td>0.25</td><td>80</td><td>18:</td></t<>	0.83 0.21 0.52 0.003 14.1 2.7 14 1.750 Li-7	0.52 0.003 14.1 2.7 14 1.750	0.003 14.1 2.7 14 1.750	14.1 2.7 14 1.750	2.7 14 1.750	14 1.750	1.750		1.7	Li-70% Si alloy + Ca, Mg	After the steel melting process	Lade	Wire	8.33×10 ⁴	0.5	0.25	80	18:
% Si alloy Initia stage of the steel melting process Lade Wire 5.09×10³ 2.6 1.02 48 % Si alloy Initia stage of the steel melting process Lade Wire 5.09×10³ 2.6 1.02 37 % Si alloy Initia stage of the steel melting process Lade Input 9.00×10⁵ 5.2 1.10 51 % Si alloy Initia stage of the steel melting process Lade Aloy input 0.004 1.0 2.50 87 % Si-0.5% Al Initia stage of the steel melting process Lade Aloy input 6.80×10⁵ 1.5 1.10 54 LiF Initial stage of the steel melting process Lade Input 7.20×10⁵ 1.2 1.20 56 LiF Initial stage of the steel melting process Lade Input 7.37×10⁵ 1.6 1.2 54 LiF Initial stage of the steel melting process Lade Input 7.37×10⁵ 1.6 1.2 54 LiF Initial stage of the steel melting process Lade Input	0.83 0.22 0.50 0.003 15.0 2.5 15 1.970	0.50 0.003 15.0 2.5 15 1.970	0.003 15.0 2.5 15 1.970	15.0 2.5 15 1.970	2.5 15 1.970	15 1.970	1.970			Li-60% Si alloy	After the steel melting process	Lade	Wire	8.95×10 ⁴	9.0	0.19	9	20
% Si alloy Initial stage of the steel melting process Lade Wire 5.09×10³ 2.6 1.02 37 % Si alloy Initial stage of the steel melting process Lade Mre 9.18×10³ 4.1 1.20 60 60 M. Si alloy Initial stage of the steel melting process Lade Input 9.00×10³ 5.2 1.10 51 51 M. Si-0.5% Al Initial stage of the steel melting process Lade Alloy input 6.80×10³ 1.5 1.10 54 54 M. Si-0.5% Al Initial stage of the steel melting process Lade Input 7.20×10³ 1.0 1.05 54 LiF Initial stage of the steel melting process Lade Input 7.20×10³ 1.6 1.2 1.20 56 LiF Initial stage of the steel melting process Lade Input 7.30×10³ 1.6 1.2 1.14 49 LiF Initial stage of the steel melting process Lade Input 7.30×10³ 0.0 1.2 5.5	0.72 0.21 0.52 0.003 23.8 1.8 24 13.200	0.52 0.003 23.8 1.8 24 13.200	0.003 23.8 1.8 24 13.200	23.8 1.8 24 13.200	1.8 24 13.200	24 13.200	13.200		_	Li-70% Si alloy	Initial stage of the steel melting process	Lade	Wire	6.29×10 ³	1.7	1.02	48	45
% Si alloy Initial stage of the steel melting process Lade N/re 9.18×10³ 4.1 1.20 60 % Si alloy Initial stage of the steel melting process Lade Input 9.00×10³ 5.2 1.10 51 % St-0.5% Al Initial stage of the steel melting process Lade Alloy input 6.80×10³ 1.0 2.50 87 % St-0.5% Al Initial stage of the steel melting process Lade Input 7.20×10³ 1.0 1.05 54 LF Initial stage of the steel melting process Lade Input 5.50×10³ 1.6 1.29 56 LF Initial stage of the steel melting process Lade Input 2.30×10³ 1.6 1.2 1.14 49 LF Initial stage of the steel melting process Lade Input 2.30×10³ 4.1 2.01 60	0.73 0.22 0.52 0.003 19.8 1.4 21 11.200	0.52 0.003 19.8 1.4 21	0.003 19.8 1.4 21	19.8 1.4 21	1.4 21	21		1.200		Li-70% Si alloy	Initial stage of the steel melting process	Lade	Wire	5.09×10 ⁻³	2.6	1.02	37	35
% Statloy Initial stage of the steel metting process Lade Alloy input 0.004 1.00 2.50 87 % St-0.5% Al Initial stage of the steel metting process Lade Alloy input 6.80×10 ⁶ 1.5 1.10 54 % St-0.5% Al Initial stage of the steel metting process Lade Input 7.20×10 ⁶ 1.0 1.05 51 U.F Initial stage of the steel metting process Lade Input 5.50×10 ⁶ 1.6 1.29 54 U.F Initial stage of the steel metting process Lade Input 5.50×10 ⁶ 1.6 1.29 54 U.F Initial stage of the steel metting process Lade Input 2.38×10 ⁶ 0.0 1.26 54 U.F Initial stage of the steel metting process Lade Input 2.30×10 ⁶ 0.0 1.26 55	0.83 0.22 0.51 0.003 24.3 1.7 25 20.200	0.51 0.003 24.3 1.7 25	0.003 24.3 1.7 25	24.3 1.7 25	1.7 25	25		0.200		Li-70% Si alloy	Initial stage of the steel melting process	Lade	Wire	9.18×10 ⁻³	4.1	1.20	09	41
Alze in thirtied stage of the steed melting process Lade Alloy input 6.80×10 ⁶ 1.5 1.10 54 % St-0.5% Al Initiad stage of the steed melting process Lade Input 7.20×10 ⁶ 1.0 1.05 54 LiF Initiad stage of the steed melting process Lade Input 5.50×10 ⁶ 1.6 1.29 56 LiF Initiad stage of the steed melting process Lade Input 5.50×10 ⁶ 1.7 1.14 49 LiF Initiad stage of the steed melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 LiF Initiad stage of the steed melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55	0.83 0.20 0.51 0.004 22.9 3.7 25 0.018	0.51 0.004 22.9 3.7 25	0.004 22.9 3.7 25	22.9 3.7 25	3.7 25	25		0.018		Li-70% Si alloy	Initial stage of the steel melting process	Lade	Input	9.00×10 ⁻⁶	5.2	1.10	51	39
% St-0.5% Al Initial stage of the steel melting process Lade Alloy input 6.80×10 ⁶ 1.5 1.10 54 % St-0.5% Al Initial stage of the steel melting process Lade Input 7.20×10 ⁶ 1.0 1.05 51 LiF Initial stage of the steel melting process Lade Input 5.50×10 ⁶ 1.6 1.29 54 LiF Initial stage of the steel melting process Lade Input 7.37×10 ⁶ 1.7 1.14 49 LiF Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 Si3 ₂ + LiF Before the steel melting process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.81 0.25 0.50 0.003 9.6 0.7 10 10 1	0.50 0.003 9.6 0.7 10	0.003 9.6 0.7 10 10	9.6 0.7 10	0.7 10 10	10 10	10		~	Li ₂ O-containing stag	Initial stage of the steel melting process	Lade	Alloy input	0.004	10.0	2.50	87	52
Initial stage of the steel melting process Lade Input 7.20×10 ⁶ 1.0 1.05 51 Initial stage of the steel melting process Lade Input 5.50×10 ⁶ 1.6 1.29 54 Initial stage of the steel melting process Lade Input 7.37×10 ⁶ 1.7 1.14 49 Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 Before the steel melting process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.82 0.25 0.50 0.003 14.5 1.4 18 0.017 29	0.50 0.003 14.5 1.4 18 0.017	0.003 14.5 1.4 18 0.017	14.5 1.4 18 0.017	1.4 18 0.017	18 0.017	0.017		%	2% Li-90% Si-0.5% Al	Initial stage of the steel melting process	Lade	Alloy input	6.80×10 ⁻⁶	1.5	1.10	54	42
LiF Initial stage of the steel melting process Lade Input 5.50×10 ⁶ 1.2 1.20 56 LiF Initial stage of the steel melting process Lade Input 5.50×10 ⁶ 1.6 1.29 54 LiF Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 SiO ₂ +LiF Before the steel melting process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.82 0.25 0.50 0.003 12.1 1.1 17 0.018	0.50 0.003 12.1 1.1 17 0.018	0.003 12.1 1.1 17 0.018	12.1 1.1 17 0.018	1.1 17 0.018	17 0.018	0.018		• ,	5%Li-89% Si-0.1% A	Initial stage of the steel melting process	Lade	Input	7.20×10 ⁶	1.0	1.05	51	39
LiF Initial stage of the steel melting process Lade Input 7.37×10 ⁶ 1.6 1.29 54 LiF Initial stage of the steel melting process Lade Input 7.37×10 ⁶ 1.7 1.14 49 SIO ₂ + LiF Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 SIO ₂ + LiF Before the steel melting process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.73 0.23 0.52 0.003 10.4 1.5 21 0.008	0.52 0.003 10.4 1.5 21	0.003 10.4 1.5 21	10.4 1.5 21	1.5 21	21		0.008		<u>H</u>	Initial stage of the steel melting process	Lade	Input	3.48×10 ⁶	1.2	1.20	56	34
LiF Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 1.7 1.14 49 LiF Initial stage of the steel melting process Lade Input 2.38×10 ⁶ 0.0 1.26 55 SiO ₃ +LiF Before the steel melting process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.72 0.20 0.52 0.004 9.2 1.1 17 0.011	0.52 0.004 9.2 1.1 17	0.004 9.2 1.1 17	9.2 1.1 17	1.1	11		0.011	1	Ή	Initial stage of the steel melting process	Lade	Input	5.50×10 ⁻⁶	1.6	1.29	54	32
LiF Initial stage of the steel melting process Lade Input 2.38×10^6 0.0 1.26 55 SiO ₂ +LiF Before the steel melting process Lade Input 7.20×10^6 4.1 2.01 60	0.81 0.19 0.51 0.004 8.5 1.0 16 0.014	0.51 0.004 8.5 1.0 16	0.004 8.5 1.0 16	8.5 1.0 16	1.0 16	91		0.014		ΉJ	Initial stage of the steel melting process	Lade	Input	7.37×10 ⁻⁶	1.7	1.14	49	32
SiO ₃ +LiF Before the steel metring process Lade Input 7.20×10 ⁶ 4.1 2.01 60	0.82 0.21 0.51 0.003 10.1 1.7 22 0.005	0.51 0.003 10.1 1.7 22	0.003 10.1 1.7 22	10.1 1.7 22	1.7 22	22		0.005		ΉÜ	Initial stage of the steel melting process	Lade	Input	2.38×10 ⁶	0.0	1.26	92	32
	0.82 0.25 0.50 0.003 9.9 1.6 20 0.018	0.50 0.003 9.9 1.6 20	0.003 9.9 1.6 20	9.9 1.6 20	1.6 20	20		0.018	ļ	Na ₂ SiO ₃ + LiF	Before the steet melting process	Lade	Input	7.20×10 ⁶	1.4	2.01	09	41

											٠ .		,															
Size of the	largest inclusion particle	(mrl)	15	7 1	15	0	0	16	0	13	15	21	20	16	11	14	19	18	19	21	38	48	33	48	41	09	20	53
	Fracture causing inclusion		SiO ₂ -rich	MgO-SiO ₂	MgO-SiO ₂	-	-	Al ₂ 0 ₃ -rich	•	CaO-SiO ₂	Al ₂ O ₃ -rich	Refractory base	SiO ₂ -rich	Al ₂ 0 ₃ -rich	MgO-SiO ₂	MgO-SiO ₂	Refractory base	Refractory base	Refractory base	Refractory base	SiO ₂ -rich	Refractory base	SiO ₂ -rich	Refractory base	SiO ₂ -rich	Refractory base	SiO ₂ -rich	Refractory base
-	L ₂ O content Fatigue strength of slag (Fracture ratio)	(%)	4	0	1	0	0	2	0	3	3	4	1	3	2	2	3	2	4	5	35	46	37	54	39	51	45	09
	Ll ₂ C content of slag	(% by mass)	0.1	0.1	0.1	0.2	0.3	0.4	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.3	0.3	0.2	0.1	0.3	0.1	3.0	0.2	7.0	0.3	5.0	0.2	4.0
Li content of	steel /Si content of steel (% by mass)	,	1.38×10 ⁻⁶	2.26×10 ⁻⁵	8.15×10 ⁻⁵	4.27×10 ⁻⁵	8.80×10 ⁻⁵	5.58×10 ⁻⁵	6.16×10 ⁻³	1.18×10 ⁻⁴	3.66×10*	8.90×10 ⁻⁴	2.35×10 ⁻⁵	1.93×10 ⁻⁴	2.54×10 ⁻⁵	1.05×10 ⁻⁴	2.94×10 ⁻⁴	4.03×10 ⁻⁴	4.58×10 ⁻⁴	9.90×10 ⁻⁴	6.21×10 ⁻⁷	1.38×10 ⁻³	6.90×10 ⁻⁷	1.47×10 ⁻²	1.24×10 ⁻⁸	1.50×10 ⁻³	6.00×10 ⁻⁷	1.17×10 ⁻³
<u> </u>	Adding st		Wire	Wire	Wire	Wire	Injection	Injection	Wire	Wire	Wire	Wire	Wire	Wire	Wire	Wire	injection	Injection	Wire	Wire	Wire	Wire	Wire	Injection	Wire	Wire	Wire	Wire
	Adding /	_	Ladle	Ladle	Ladle	Ladle	Ladle In	Ladle	<u>P</u>	g.	Ladle	Ladle	Ladie	Ladle	Ladie	Ladle	ie E	Ladle In	TD T	QW	Ladle	Ladle	Ladle	Ladle In	Ladle	Ladle	Ladle	Ladle
Alkaline metal addidng method	Adding time	•	After the steel melting process	After the steel melting process	After the steel melting process	After the steel melting process	After the steel melting process	After the steel melting process	After the steel melling process	After the steel melting process	After the steel melting process	After the steel melting process	After the steel melting process	Li-70% Si alloy+Ca, Mg After the steel melting process	After the steel melting process	After the steel melling procéss	After the steel melting process	Initial stage of the steel melting process										
	Li-containing material		Li ₂ CO ₃	Li ₂ CO ₃ +Ca	Li ₂ CO ₃	Li2CO3+Ca, Mg	Li ₂ CO ₃	Li ₂ CO ₃	Li ₂ CO ₃	Li ₂ CO ₃	Li-70% Si alloy	Li-70% Si alloy + Ca	Li ₂ CO ₃	i-70% Si alloy+Ca, Mg	Li ₂ CO ₃	Li-70% Si alloy	별	Li-70% Si alloy	<u>"</u>	Li-70% Si alloy	Li-95% Si alloy	Li-70% Si alloy	5	Li-70% Si alloy				
	:3		0.020	0.330	1.190	0.624	0.986	0.815	0.893	1.708	5.300	13.00	0.470	3.887	0.510	2.110	5.90	8.10	9.20	19.90	600.0	20.20	0.010	2.140	0.018	21.80	0.012	23.00
	0	_	10	85	24	22	21	21	. 12	8	22	22	6	19	15	19	21	22	18	30	21	24	17	21	16	22	22	19
	Mg	mdd)	1.0	1.4	1.8	3.3	4.3	5.1	1.3	1.6	7.5	4.1	3.2	2.8	1.1	1.4	0:1	1.6	2.7	8.8	0.9	4.0	7.0	4.0	8.0	4.0	6:0	3.0
	ű		10.2	18.1	22.0	17.3	16.1	20.9	19.8	19.0	24.3	23.1	17.8	17.1	15.0	20.2	21.0	20.7	17.0	38.0	9.1	23.2	8.0	19.9	7.2	25.1	80	20.2
	>					0.10	0.10	0.10	60:0	60:0	0.09	0.09	0.10	0.10	0.10	0.10	0.10	01.0	0.10	0.10			0.10	0.10	0.09	0.09	0.10	0.10
Composition	z					0.25	0.25	0.25					0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25			0.25	0.25			0.25	0.25
S	ö		0.70	0.71	0.71	0.71	0.70	0.70	0.65	0.65	0.65	0.65	06:0	06:0	06:0	06.0	06:0	06:0	0.30	06:0	17.0	0.70	99.0	0.70	0.65	0.65	06:0	0.90
	IA .	(% by mass)	0.004	0.003	0.003	0.003	0.004	0.005	0.003	0.004	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.004	0.003	0.004	0.003	0.004	0.005	0.005
	Mn	%)	0.71	0.70	0.70	0.70	0.70	0.70	. 0.65	0.65	0.65	0.64	0.89	06:0	06:0	06:0	06:0	06:0	06:0	06:0	0.71	0.73	0.71	0.71	0.65	0.65	0.89	0.89
	ফ		1.45	1.46	1.46	1.46	1.45	1.46	1.45	1.45	1.45	1.46	2.00	2.01	2.01	2.01	2.01	2.01	2.01	2.01	1.45	1.46	1.45	1.46	1.45	1.45	2.00	2.00
	U		0.55	0.55	0.55	0.55	0.58	09:0	0.63	0.65	0.63	0.64	09:0	19:0	0.61	0.61	0.61	0.61	0.61	0.61	0.58	0.55	0.58	0.58	0.63	0.65	09:0	09:0
	Sample No.	L	81	B2	B3	B4	B2	98	87	88	68	B10	B11	B12	B13	B14	815	B16	817	B18	B19	B20	821	B22	B23	B24	825	B26

TABLE 3

	Spill	conent conte	Component content (% by mass)	ass)			S	Composition of inclusion (%		by mass)				Li adding method	Number of oxide		Ciro of the
ımple No.	O	ιΣ	M	₹	S	SiO ₂	MgO	Ab03	Na ₂ 0	K ₂ 0	O ² iJ	Na ₂ O+K ₂ O+Li ₂ O	Li-containing material	Adding time	inclusion particles of 20 µm or above (Number per 50g of steel)	Drawabilty (Frequency of breakage)	kargest inclusion particle (µm)
A24	0.72	0.21	0.52	0.003	39.8	39.3	2.1	18.1	0.0	0.0	0.7	0.7	₅ 00 ₃ 1	Final stage of the steel melting process	0.20	10	22
A25	0.82	0.19	0.51	0.004	37.2	39.0	3.7	16.0	0.0	0.0	4.1	4.1	Li-70% Si alby	Final stage of the steel melting process	0.10	5	19
A26	0.81	0.21	0.50	0.003	20.8	41.9	2.1	15.6	3.4	4.1	12.1	19.6	Li-70% Si alby	Final stage of the steel melting process	60:0	2	17
A27	0.72	0.18	0.49	0.003	29.0	45.0	18.0	3.0	0.0	0:1	3.0	4.0	Li-70% Si alby	Final stage of the steel melting process	0.16	9	20
A28	0.72	0.21	0.52	0.004	15.0	47.4	9.2	16.0	2.3	0:0	10.1	12.4	Li-70% Si alby	Final stage of the steel melting process	0.13	7	18
A29	0.83	0.19	0.50	0.003	20.1	63.1	1.8	8.0	0.5	2.6	3.9	7.0	Li-70% Si alby	Final stage of the steel melting process	0.19	- 11	22
A30	0.84	0.20	0.48	0.003	26.4	32.0	2.5	34.0	0.0	0:0	5.1	5.1	Li-70% Si alby	Final stage of the steel melting process	0.21	6	21 .
A31	0.70	0.18	0.49	0.003	30.0	0.85	1.6	10.0	0:0	0.0	0.4	0.4	Li ₂ CO ₃	Initial stage of the steel melting process	08.0	31	32 ·
A32	0.73	0.20	0.51	0.003	25.0	39.0	1.0	14.0	0.0	0:0	21.0	21.0	Li-70% Si alby	Initial stage of the steel melting process	0.55	28	41
A33	0.73	0.21	0:00	0.004	55.2	25.0	2.2	16.6	1:0	0:0	0.0	1.0	•		29:0	35	45 .
A34	0.74	0.20	05.0	0.003	14.0	61.0	2.5	21.3	0:0	1.2	0.0	1.2	. •	•	0.45	40	36
A35	0.81	0.19	0.52	0.003	28.7	31.0	3.4	36.0	0:0	0.0	0.0	6.0	Li ₂ CO ₃	Initial stage of the steel melting process	0.38	24	31
A36	0.83	0.20	0.49	0.004	11.0	20.7	20.5	16.2	9.0	0:0	1.0	1.6	FOO ₄ 1	Initial stage of the steel melting process	0.54	46	37
A37	0.83	0.20	0.50	0.003	15.0	71.0	3.9	1.8	0.5	0.4	1.1	2.0	Li ₂ CO ₃	Initial stage of the steel melting process	0.93	58	33
A38	0.83	0.19	0.51	0.004	45.0	.18.0	2.6	33.4	0:0	0.4	9.0	1.0	Li ₂ CO ₃	Initial stage of the steel melting process	0.41	22	32

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TABLE 4

B27 0.55 B28 0.58 B30 0.60 B31 0.63	. NA NA	₹				-	-	-	+	Na. O. K.	. -				Fracture ratio	Inclusion causative of fracture	Size of the largest inclusion particle
0.55		₹		-	_		_	_		_				:			
			<u>ა</u>	 Z	>	ა დ	 	 Ogw 	 S 		 	05U+05U+4504U50	O Adding position	Adding time			(met)
	1.45 0.71	0.004	0.70			35.0	42.7	2.9	18.8	0.0	0.0	0.6	8.6 L ₂ CO ₃	Final stage of the steel melting process	82	MgO-SiO ₂	25
	1.46 0.70	0.003	17.0	0.25	0.10	35.2	40.5	2.7	18.0	0.0	1.0	2.6 3.	3.6 L ₂ CO ₃	Final stage of the steel melting process	0	•	
	1.45 0.70	0.004	0.70	0.25	0.10	25.6	41.5	17.3	10.2	1.2	0.0	4.2 5.	5.4 L ₂ CO ₃	Final stage of the steel melling process	0	•	
	1.46 0.70	0.005	0.70	0.25	0.10	22.4	37.8	2.4	33.8	0:0	0;	3.6	3.6 L½CO ₃	Final stage of the steel melting process	8	Al ₂ O ₃ -rich	16
	1.45 0.65	0.003	0.65		60.0	21.2	40.2	2.5	28.6	2.1	1.5	3.9 7.	7.5 L ₂ CO ₃	Final stage of the steel melting process	0	•	0
B32 0.65	1.45 0.65	0.004	0.65		0.09	36.3	46.0	5.6	4.9	0.0	0.0	7.2	7.2 Li-70% Si alloy	Final stage of the steel melling process	3	CaO-SiO ₂	13
B33 0.60	2.00 0.89	0.005	0.90	0.25	0.10	18.0	8.69	2.8	7.2	0:0	0:0	2.2 2.	2.2 L ₂ CO ₃	Final stage of the steel melling process	18	SiO ₂ -rich	25
B34 0.61	2.01 0.90	0.005	06:0	0.25	0.10	15.1	45.0	2.2	19.5	0:0	0:0	18.2	.2 Li-70% Si alloy	Final stage of the steel melling process	5	A ₂ O ₃ -rich	92
B35 0.55	1.44 0.69	0.003	0.70			21.5	60.3	2.9	13.2	0.0	0:0	2.1	2.1 L ₂ CO ₃	Final stage of the steel melting process	0	MgO-SiO ₂	\$2
B36 0.58	1.46 0.70	0.003	0.71	0.25	0.10	20.3	65.2	2.4	10.2	0.0	0:0	1.9	1.9 L ₂ CO ₃	Final stage of the steel melling process	3	MgO-SiO ₂	19
B37 0.63	1.45 0.65	0.003	0.65		90.0	20.2	63.8	2.9	7.2	0:0	0:0	5.9 5.	5.9 Li-70% Si alloy	Final stage of the steel melling process	0	MgO-SiO ₂	92
B38 0.60	2.00 0.89	0.005	0.90	0.25	0.10	19.0	62.5	2.8	9.2	0:0	0:0	6.5 6.	6.5 Li-70% Si alloy	Final stage of the steel melting process	0	MgO-SiO ₂	0
B39 0.56	1.45 0.71	0.003	17.0			19.2	64.8	2.4	13.2	0.0	0.0	0.4 0.	0.4 L ₂ CO ₃	Initial stage of the steel melting process	35	SiO ₂ -rich	32
B40 0.55	1.46 0.73	0.004	0.70			50.9	43.1	2.5	12.3	0.0	0:0	21.2 21.2	.2 Li-70% Si alloy	Initial stage of the steel melting process	75	Refractory base	84
B41 0.55	1.46 0.68	0.005	0.70			15.0	45.0	2.3	16.2	2.5	1.2	17.8 21.5	.5 Li-70% Si alloy	Initial stage of the steel melting process	88	Refractory base	29
B42 0.58	1.45 0.71	0.003	0.68	0.25	1.0	55.9	32.6	2.1	8.4	0:0	0.0	1.0	1.0 L ₂ CO ₃	Initial stage of the steel melting process	35	CaO-rich	35
B43 0.58	1.46 0.71	0.004	0.70	0.25	0.1	14.0	62.3	1.9	21.0	0:0	0.0	0.8 0.	8.8 Li ₂ CO ₃	Initial stage of the steel melting process	48	SiO ₂ -rich	£3
B44 0.55	1.46 0.71	00:00	0.70		•	22.4	39.7	1.7	35.1	0.0	0.0	1.1	1.1 Li ₂ CO ₃	Initial stage of the steel melting process	98	Al ₂ O ₃ -rich	93
845 0.63	1.45 0.65	0.003	99:0		0.09	29.2	30.0	1.5	36.0	0.0	0.0	1.3	1.3 Li ₂ CO ₃	Initial stage of the steel melting process	æ	Al ₂ O ₃ -rich	34
B46 0.65	1.45 0.65	0:004	0.65		0.09	16.4	53.1	20.1	6.9	0.0	0.0	1.1	1.1 Li ₂ CO ₃	Initial stage of the steel melling process	25	MgO-SiO ₂	32
B47 0.61	2.01 0.90	0.005	0.90	0.25		16.0	71.8	2.7	8.6	0.0	0.0	0.9 0.	6.9 Li ₂ CO ₃	Initial stage of the steel melting process	99	SiO ₂ -rich	45
B48 0.60	2.00 0.89	0.005	0.90	0.25	0.1	53.5	18.9	2.9	23.7	0.0	0.0	1.0	1.0 L ₂ CO ₃	Initial stage of the steel melting process	38	CaO-rich	48